

# **URBAN WATER USE CHARACTERISTICS IN THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA**



**Metropolitan Water District of Southern California**

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**INTRODUCTION**

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**PURPOSE**

Planning for future water supplies requires a detailed knowledge of the water agency's service area and its water use characteristics. Forecasting water demands must take into account the systematic forces which influence urban water use. Factors which can cause changes in water demand include population, housing, commercial and industrial activities, weather, income, price of water service, plumbing fixtures, and others. Evaluation of water conservation, which should be included in projections of water demand, also requires information on how water is used, by whom, and under what conditions. The purpose of this report is to present the components and characteristics of urban water use in areas served by the Metropolitan Water District of Southern California (Metropolitan). These components represent the major types (or sectors) of municipal and industrial (M&I) water use, as well as the seasonal breakdown of water use. The report will also provide information on specific uses of M&I water, especially residential water use which comprises over 65 percent of the water used in Metropolitan's service area.

**SOURCES OF DATA**


Metropolitan uses an econometric water demand forecasting model known as the MWD-MAIN model. This model is based on the IWR-MAIN forecasting model, which was developed for the U.S. Army Corps of Engineers, Institute for Water Resources. The model was calibrated to Metropolitan's service area using data from 14 large retail water agencies in Southern California. Water demand is projected by customer class, including residential, commercial/institutional, industrial, and other/losses. MWD-MAIN requires data on population, number and types of housing units, employment in various commercial enterprises and industries, personal income, prices of water service,

climate, and estimates of long-term water conservation. For planning purposes, Metropolitan uses projections of demographic data developed by the regional governments, the Southern California Association of Governments (SCAG) and the San Diego Association of Governments (SANDAG).

In order to calibrate and verify the demand model, Metropolitan had to obtain data on how water is being used in its service area. For this purpose, Metropolitan initiated several large-scale water use surveys. These surveys were incorporated into the demand analysis using the MWD-MAIN model, and are reported in Metropolitan's Interim Report No. 4 on Municipal and Industrial Water Use. These surveys and Interim Report No. 4 are the source documents for this report. The following briefly describes each of these reports.

*Seasonal Components of Urban Water Use in Southern California (February, 1990)*

This survey was undertaken to estimate the amount of seasonal variation in each water use class. Bi-monthly water use data was obtained from 28 retail water agencies for the years 1980 through 1987 (although not every agency had continuous data for every year). The data were analyzed to develop estimates of seasonal/nonseasonal water use and indoor/outdoor water use for the residential, commercial, industrial, and public/other sectors. In addition, the report estimated the household water use for single-family and multifamily residences (based on 1985 water use and demographic data). The water agencies used in this study are primarily mature urban centers. However, within Metropolitan's service area there also exist many transitional rural areas in which household water use is greater due to hotter inland climate and larger lot sizes. Consequently, the household water use presented in this report is somewhat lower than the average household water use presently found in Metropolitan's service area.



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### *Commercial and Industrial Water Use in Southern California (March, 1990)*

Commercial and industrial water use currently represents about 23 percent of M & I water use in Southern California. In 1989, Metropolitan conducted a nonresidential survey of more than 3,000 commercial and industrial establishments in Southern California. The purpose of the survey was to obtain data on per employee water use for demand forecasting. For each establishment, employment, water use, and industry classification were collected and a model was developed to obtain statistical estimates of water use per employee, measured as gallons per employee per day (GED). Estimates of GED were developed for homogeneous categories based on industry classification (SIC codes). In addition, the study identified the larger water using industries, a factor which is useful in designing conservation programs.

### *Water Demand of Detached Single-Family Residences (August, 1990)*

A detailed study of single-family residential water use was conducted in order to explore the relationships between the known determinants of water use and to verify the water demand models used in the MWD-MAIN model. Unlike the demand models in MWD-MAIN, which used aggregate agency-level

data, the demand models presented in this report were based on household-level data. A detailed survey of about 1,000 homes in five communities in Southern California was conducted to obtain information on household size, income, lot size, presence of swimming pool, household plumbing fixtures, conservation activities, and others. This survey information was statistically modeled with actual monthly household water use for the years 1985 through 1988. In addition, estimates of price elasticity for single-family water demand were derived.

### *Municipal and Industrial Water Use, Interim Report No. 4 (June, 1991)*

The results from the above-mentioned studies, along with demographic projections from SCAG's GMP (1989) and SANDAG's Series 7 forecast (1988), were incorporated into the MWD-MAIN model to project long-term M&I water demands. In addition, estimates of long-term water conservation, including the state-wide "best management practices" (BMPs), were incorporated. The resulting water demands and estimates of per capita use, per household use, and per employee use, represent Metropolitan's current characteristics.





## SERVICE AREA OVERVIEW

The Metropolitan Water District of Southern California is a wholesale water provider which serves the coastal plain of Southern California. Figure 1 shows the service area of Metropolitan, which covers significant portions of the following six counties: Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura. The service area of Metropolitan is a diversified economy with a strong commercial and industrial base. The service area spans three

major climate zones, where cooler temperatures and greater rainfall are typical for the coastal region, while hotter temperatures and less rainfall represent the inland desert areas. Table 1 summarizes the current 1990 demographics and land area of Metropolitan. Since 1970, this service area has sustained one-half of California's population (see figure 2).



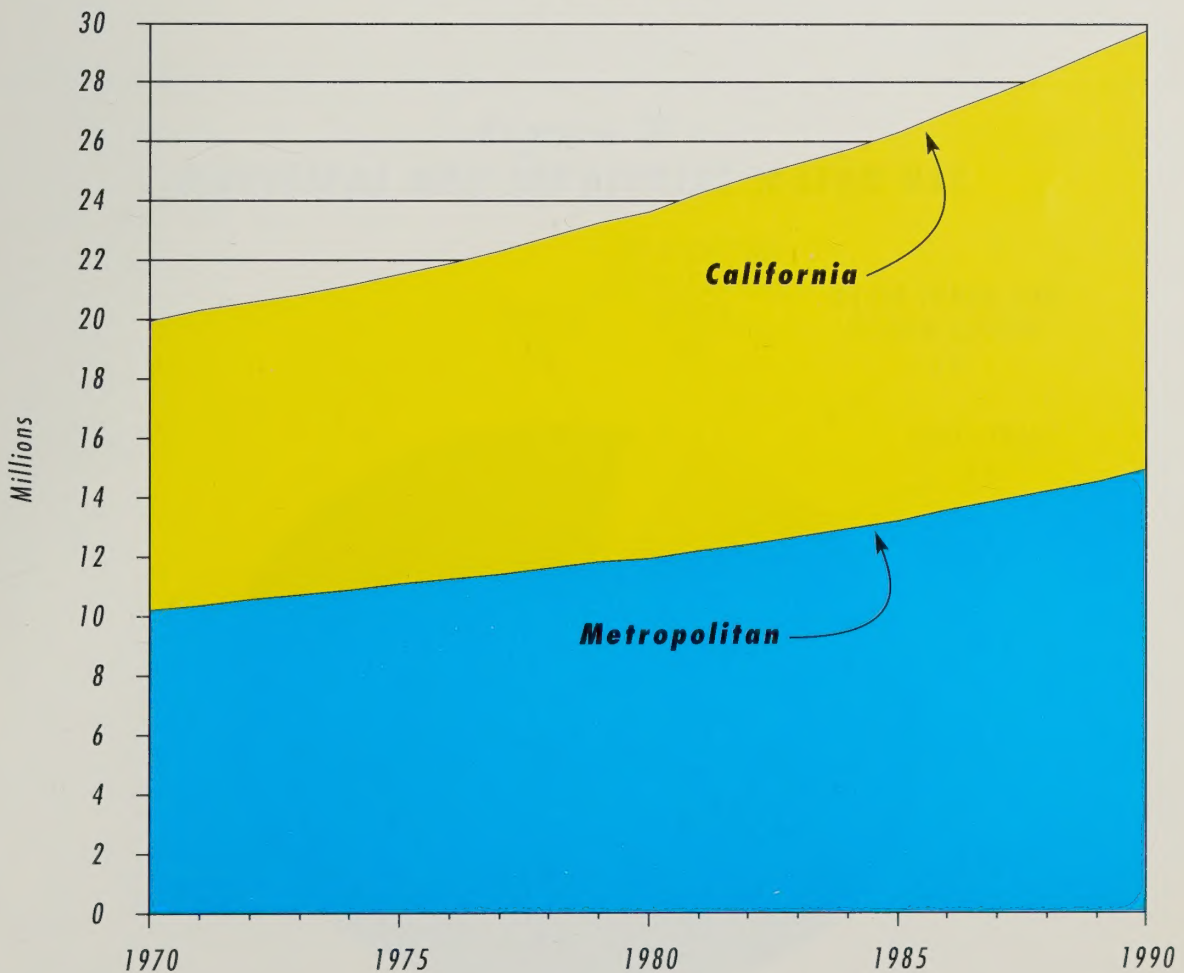




**TABLE 1**  
**METROPOLITAN'S SERVICE AREA STATISTICS IN 1990**

Population (millions)	14.90
Number of Households (millions)	5.21
Persons Per Household	2.86
Commercial/Public Employment (millions)	5.75
Industrial Employment (millions)	1.39
Total Employment (millions)	7.14
Land Area (square miles)	5,140
Assessed Valuation (\$ billions)	671.70

**Figure 2**  
**POPULATION**







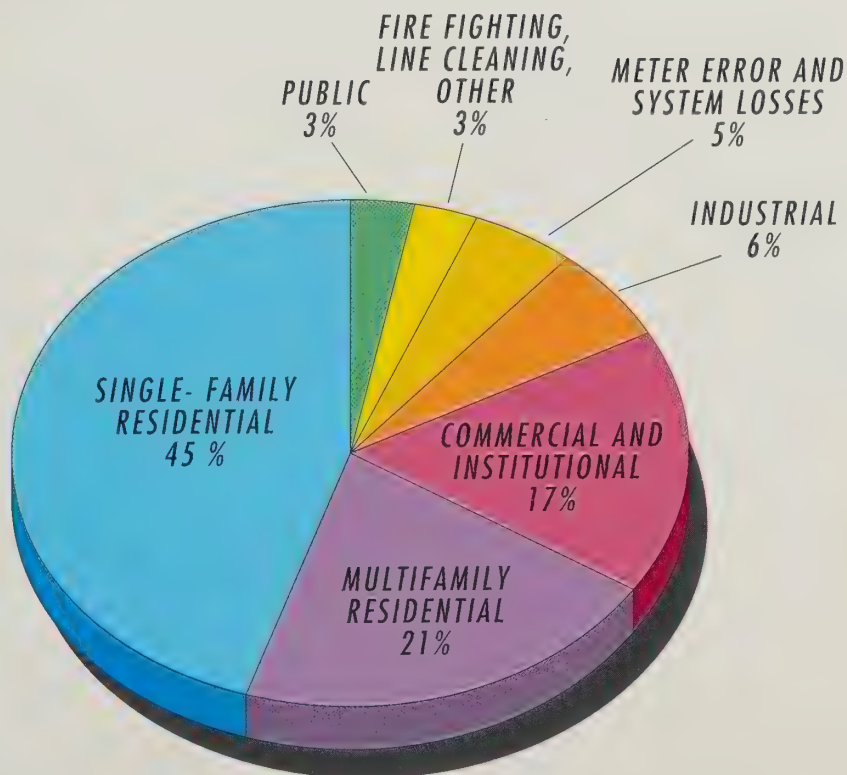
## URBAN WATER USE OVERVIEW

Typically, urban water use consists of residential, commercial, industrial, public, and other purposes which include fire-fighting, line cleaning, and system losses. The largest sector of urban water use in Metropolitan's service area is residential, accounting for over 65 percent of the M & I total. Commercial, industrial, public irrigation and other uses (including system losses) follow in that order. Figure 3 shows the current breakdown of urban water use for Metropolitan.

Commonly, urban water use is expressed in units of gallons per capita per day (GPCD) so that comparisons can be made over time and from one area to the next. In general, GPCD does not express the

amount of water used by an individual, because it includes all categories of urban use (residential, commercial, industrial, firefighting, and other). Therefore, per capita water use is best expressed by category of use within each water service area. Under normal conditions (weather and economy), total urban per capita water use in Metropolitan's service area is estimated to be about 195 GPCD. Of this, about 13 to 15 GPCD is reclaimed wastewater, which is used for groundwater recharge, irrigation of large public areas and golf courses, and some direct use for commercial and industrial activities. Table 2 presents the breakdown of normal per capita use within Metropolitan's service area.

**Figure 3**  
**MUNICIPAL AND INDUSTRIAL WATER USE**







**TABLE 2**  
**PER CAPITA WATER USE**  
**(Under Normal Weather)\*\***

Sector	GPCD
Residential	130
Commercial	33
Industrial	11
Public Uses	7
Other (including system losses)	<u>14</u>
Total Urban Per Capita*	195

\* Includes 13 to 15 GPCD of wastewater reclamation and reuse.  
 \*\* Annual rainfall of 13 inches and mean annual temperature of 65°F.

### *Determinants of Water Use*

The water uses shown in Figure 1 and Table 2 represent average water use characteristics for Metropolitan's service area. Water use varies from community to community, according to differences in climate, employment base, and other factors.

In the pages which follow, the variation in water use is examined according to the underlying determinants of:

- (1) Family size;
- (2) Mix of housing stock (multifamily vs. single-family);
- (3) Personal income;
- (4) Labor participation rates (percent of people in the work force);
- (5) Mix of commercial and industrial activities;
- (6) Climate; and
- (7) Plumbing fixtures and water conservation.





## RESIDENTIAL WATER USE

Residential water use in Metropolitan's service area is the largest component of urban water demand. There are many factors which affect residential water demand. Factors which have short-run influences on residential water demand include: (1) personal income; (2) water rates and price; (3) weather; and (4) short-term conservation practices. Factors which have long-run influences on residential water demand include: (1) standard of living; (2) persons per household; (3) housing type; (4) irrigable landscape area; (5) water-using appliances and plumbing fixtures; and (6) long-term conservation practices. These factors not only influence the levels of water demand, but also how much of that demand occurs

indoors and outdoors. For example, those homes with higher standards of living and larger lot sizes generally have greater outdoor water use.

Residential water use can be expressed in several ways — gallons per capita, gallons per household, or gallons per device or type of use. Table 3 presents typical levels of household water use by type of device or application. These data are useful for designing water conservation programs. For example, showerhead and toilet flow reductions under recent plumbing codes are shown in the table.

**TABLE 3**  
**TYPICAL RESIDENTIAL WATER USE BY ACTIVITY**

### INDOOR USES:

Bath	20 gallons per average bath
Shower (10 minutes)	
4 gpm (non-conserving, pre-1979 code)	40 gallons per shower
2.5 gpm (conserving, 1979 code)	25 gallons per shower
Toilet (5 flushes per person)	
5-7 gallons/flush (non-conserving, pre-1979 code)	30 gallons per person per day
3.5 gallons/flush (1979 code)	18 gallons per person per day
1.6 gallons/flush (1992 code)	8 gallons per person per day
Clotheswasher	45 gallons per load
Dishwasher	15 gallons per load
Cooking	5 gallons per day
Bathroom faucets	3 gallons per day

### OUTDOOR USES:

Landscape Irrigation	250-350 gallons per application
Car Washing* (10 minutes of washing and rinsing)	100-150 gallons per use of hose

\* Automatic car washes use between 12-45 gallons per car, depending on the amount of recycled water used.



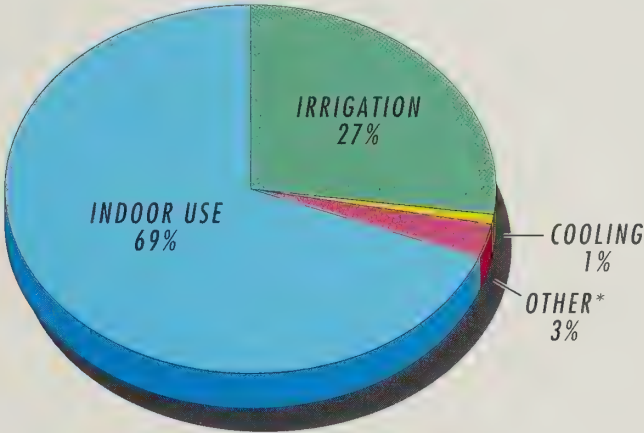


Figure 4 shows the average residential use in Metropolitan's service area, including the seasonal breakdown of indoor and outdoor uses. Figure 5 presents average annual residential water use by climatic region. Average daily residential water use (per household and per capita) can also be expressed

according to the various indoor and outdoor activities, such as showers, toilets, clothes washing, irrigation — see Table 4. These estimates are only typical, and would vary from household to household depending on family size, lot size, appliances, and so on.

**Figure 4**  
**AVERAGE RESIDENTIAL WATER USE**

PER HOUSEHOLD 380 gallons per day  
PER PERSON 135 gallons per day



*\*Includes swimming pool use, car washing, and other outdoor uses.*

**Figure 5**  
**AVERAGE RESIDENTIAL WATER USE BY CLIMATE REGION**

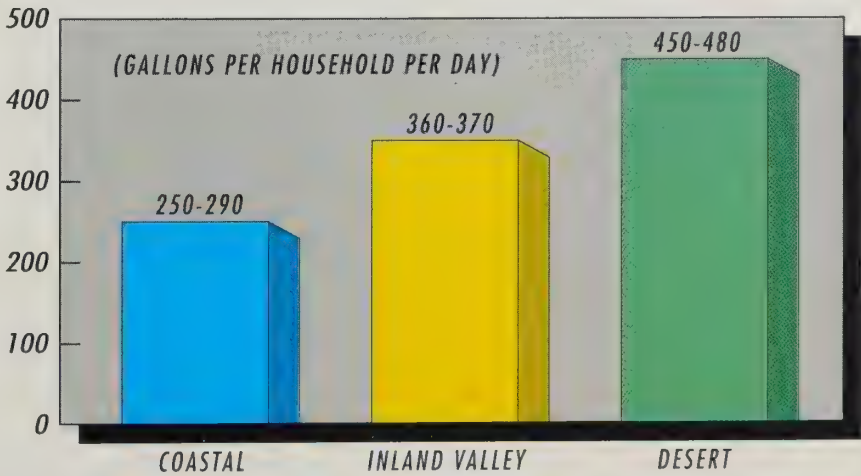




TABLE 4  
AVERAGE DAILY RESIDENTIAL WATER USE BY CATEGORY  
IN METROPOLITAN'S SERVICE AREA

Category of Water Use	Gallons Per Person	Gallons Per Household
<b>Indoor:</b>		
Toilets	30	84
Showers/Bath	26	73
Clotheswashing	20	56
Faucets (cooking/cleaning)	12	34
Dishwashing	5	15
Subtotal	93	262
<b>Outdoor:</b>		
Landscape Irrigation, Gardening	36	101
Other	6	17
Subtotal	42	118
<b>TOTAL</b>	<b>135</b>	<b>380</b>





## SINGLE-FAMILY RESIDENTIAL WATER USE

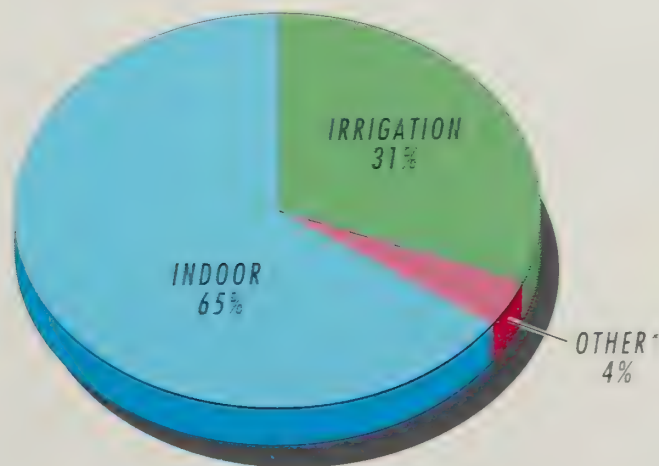
Residential water use can be divided into two broad categories — single-family and multifamily. In the past, single-family housing has grown faster than multifamily housing. However, this trend is changing as land availability decreases. Currently, about 56 percent of the total housing stock in Metropolitan is single-family, while the remaining 44 percent is multifamily. By the year 2010, it is projected that single-family will account for 52 percent, while multifamily will account for 48 percent. Single-family homes typically use more water than multifamily homes due to larger lot sizes, larger family sizes, and more water-using appliances. Single-family water use accounts for 69 percent of the total residential water demand and 45 percent of the total urban (M&I) water demand. Figure 6 presents the average single-family water use and its seasonal breakdown

(percent indoor and outdoor uses), while Table 5 presents the average single-family water use by category. Studies by Metropolitan and others show that outdoor water use (mainly irrigation) is about 35 percent of average annual use for single-family homes.

Because single-family water demand represents almost 70 percent of overall residential water demand, it is important to understand the factors which influence household water use. In 1988, a survey of households was conducted to determine the impacts that detailed demographic, economic and social characteristics have on single-family water use. The data collected for this study was at the household level.

**Figure 6**  
**AVERAGE SINGLE-FAMILY WATER USE**

PER HOUSEHOLD      465 gallons per day  
PER PERSON (*capita*)   150 gallons per day



\*Other includes swimming pool use, car washing, and other outdoor water uses.





TABLE 5  
AVERAGE DAILY SINGLE-FAMILY WATER USE BY CATEGORY  
IN METROPOLITAN'S SERVICE AREA

Category of Water Use	Gallons Per Person	Gallons Per Household
<b>Indoor:</b>		
Toilets	30	93
Showers/Bath	27	84
Clotheswashing	21	65
Faucets (cooking/cleaning)	13	40
Dishwashing	6	19
Subtotal	97	301
<b>Outdoor:</b>		
Landscape Irrigation, Gardening	46	143
Other	7	21
Subtotal	53	164
<b>TOTAL</b>	<b>150</b>	<b>465</b>

About 1,000 single-family homes were surveyed to obtain demographics and socioeconomic data. This data was statistically compared to actual water use in order to determine the relationship between these variables and water use. The price for water service

was also collected to estimate the price elasticity of demand (responsiveness to price). The following represents some of the more important findings of this study:

**A 10 Percent Increase In:**

**Will Lead To A:**

Average Price of Water (\$/ccf) .....	2.5 percent decrease in water use
Lot Size (acres) .....	2.6 percent increase in water use
Household Income (\$) .....	1.3 percent increase in water use
Persons Per Household .....	3.1 percent increase in water use
Number of Children (age < 19) .....	0.6 percent increase in water use



- ☐ Homes with 3 or more bathrooms are expected to use 10 percent more water than homes with fewer than 3 bathrooms.
- ☐ Homes with swimming pools are expected to use 12 percent more water than homes without swimming pools.
- ☐ Homes with automatic sprinkler systems are expected to use 22 percent more water than homes without automatic sprinklers.





## MULTIFAMILY RESIDENTIAL WATER USE

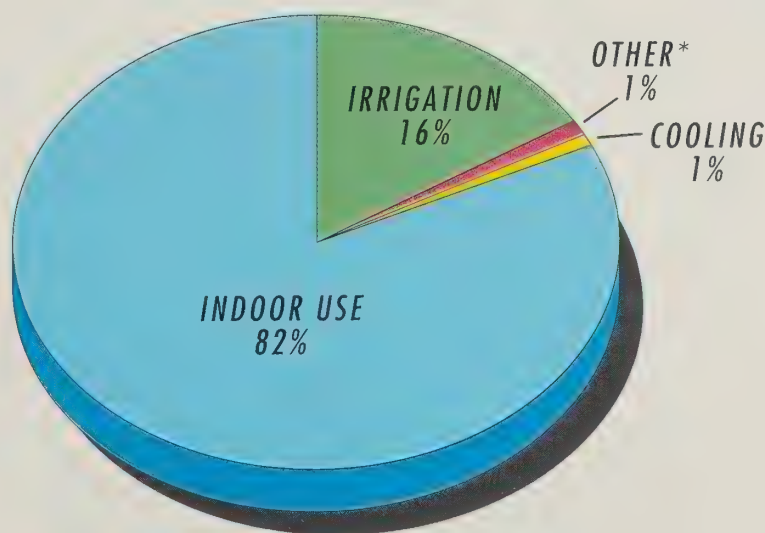
The other major category of residential water use is multifamily. Multifamily refers to those housing units not classified as detached single-family and includes apartments, condominiums, trailer parks, and townhomes. Unfortunately, few studies have been conducted using detailed household-level data for multifamily due to the problems associated with data collection. Because most multifamily units are master-metered (not individually metered like single-family), household-level water use data are difficult to obtain. Therefore, demand models for

multifamily must rely solely on aggregate data provided by the water agency. Water sold under the user account "multifamily" is divided by the estimated number of living units in the service area to obtain household-level water use. This is the approach used by Metropolitan using the MWD-MAIN model. Figure 7 presents the average multifamily water use and its seasonal breakdown, while Table 6 presents the average multifamily water use by category.

**Figure 7**  
**AVERAGE MULTIFAMILY WATER USE**

*PER HOUSEHOLD 265 gallons per day*

*PER PERSON 110 gallons per day*



*\* Other Includes swimming pool use and other outdoor water uses.*



**TABLE 6**  
**AVERAGE DAILY MULTIFAMILY WATER USE BY CATEGORY**  
**IN METROPOLITAN'S SERVICE AREA**

Category of Water Use	Gallons Per Person	Gallons Per Household
<b>Indoor:</b>		
Toilets	30	72
Showers/Bath	25	61
Clotheswashing	17	41
Faucets (cooking/cleaning)	13	31
Dishwashing	<u>4</u>	<u>10</u>
Subtotal	89	215
<b>Outdoor:</b>		
Landscape Irrigation	18	43
Cooling	1	2
Other	<u>2</u>	<u>5</u>
Subtotal	21	50
<b>TOTAL</b>	<b>110</b>	<b>265</b>





## COMMERCIAL AND INDUSTRIAL WATER USE

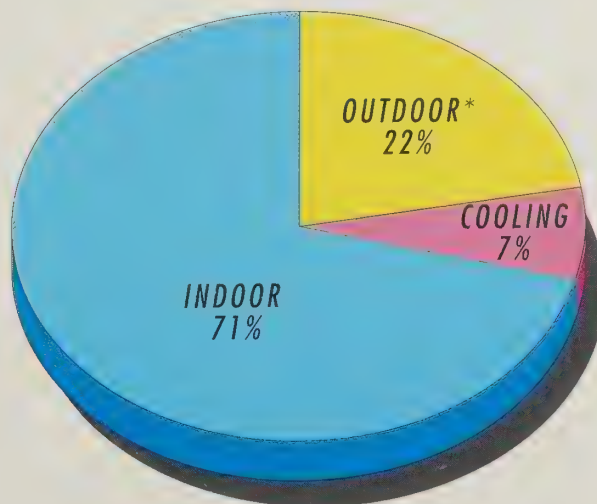
### COMMERCIAL/INSTITUTIONAL WATER USE

Commercial and institutional water demand includes water used by businesses, services, government, and institutions (such as hospitals, schools, and colleges). This sector accounts for about 17 percent of the overall M&I water demand. It is projected that by the year 2010, this sector will account for over 18 percent of total M&I water demand. Currently in 1990, there are an estimated 354,000 commercial and institutional establishments in Metropolitan's service area. The number of full-time jobs created by these establishments totals over 5.7 million, or on average about 16 employees per establishment. Figure 8 shows the average commercial/institutional water use and seasonal breakdown.

The most recent studies on outdoor water use in Metropolitan's service area indicates that outdoor water use in this sector is about 20 percent, much less than previously assumed. Most of the outdoor water use is for irrigation of landscaping. A significant amount of water is also used for cooling purposes. Not every commercial establishment uses water for cooling purposes, but on average it accounts for over 7 percent of the total annual water demand. Figure 9 shows the largest commercial and institutional water users based on a recent survey on nonresidential water use. The top users include: schools, hospitals, hotels, amusement, colleges, and restaurants. These categories not only use the most water, but are also projected to grow the fastest among the commercial sector.

**Figure 8**  
**AVERAGE COMMERCIAL/INSTITUTIONAL**  
**WATER USE**

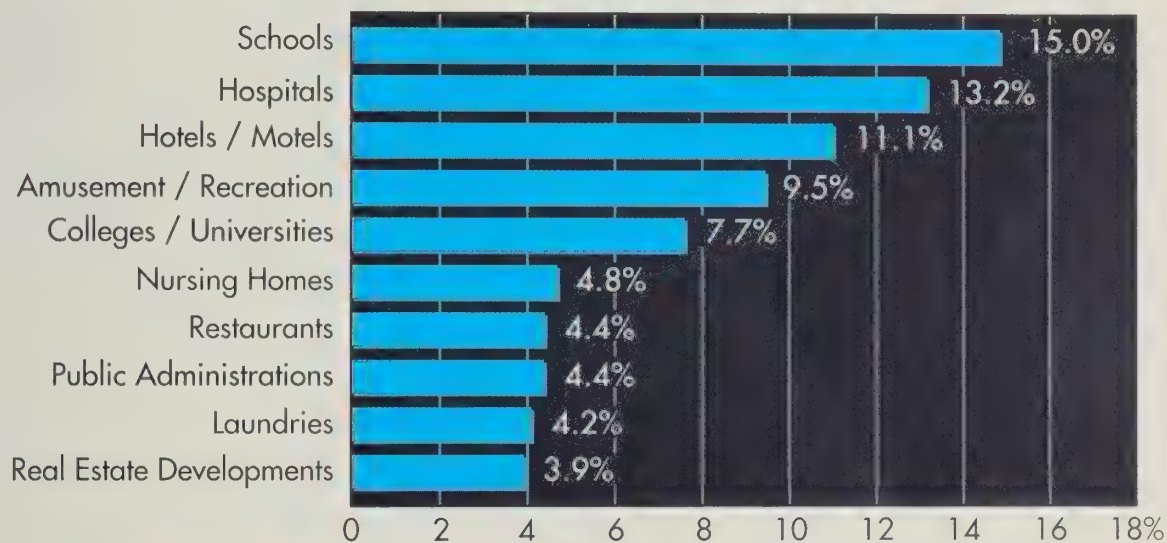
PER ESTABLISHMENT	1,480 gallons per day
PER EMPLOYEE	92 gallons per day
PER PERSON (capita)	35 gallons per day



*\*Includes irrigation and other outdoor water uses.*



**Figure 9**  
**THE LEADING COMMERCIAL AND INSTITUTIONAL USERS OF MWD WATER**



Note: Other commercial and institutional users make up 21.9% of total water use in this sector.





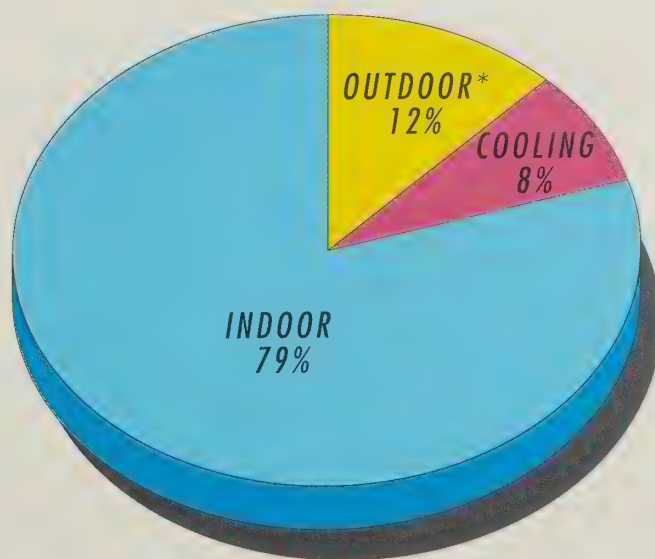
## INDUSTRIAL (MANUFACTURING) WATER USE

The other major economic sector of water use is industrial. This includes all manufacturing establishments. Currently, this sector accounts for about 6 percent of the total M&I water demand in Southern California. It is projected that by the year 2010, industrial water use will only account for 5 percent of the overall M&I demand. This decrease is due to several factors. The first relates to improved recycling and reuse technologies used by the manufacturing sector. The second relates to an actual slowing down of the heavy manufacturing that was

once typical of Southern California. There are currently about 31,000 industrial establishments and about 1.4 million employees. Figure 10 shows the average industrial water use and seasonal breakdown. Outdoor water use in this sector is much lower than the residential and commercial sectors and is mainly used for dust control and some landscape irrigation. Figure 11 shows the largest industrial water users. The top users include: electronics, aircraft, petroleum refining, beverages, and other high-tech industries. Many of these top users are projected to level off or even decline in terms of employment growth and water use.

**Figure 10**  
**AVERAGE INDUSTRIAL WATER USE**

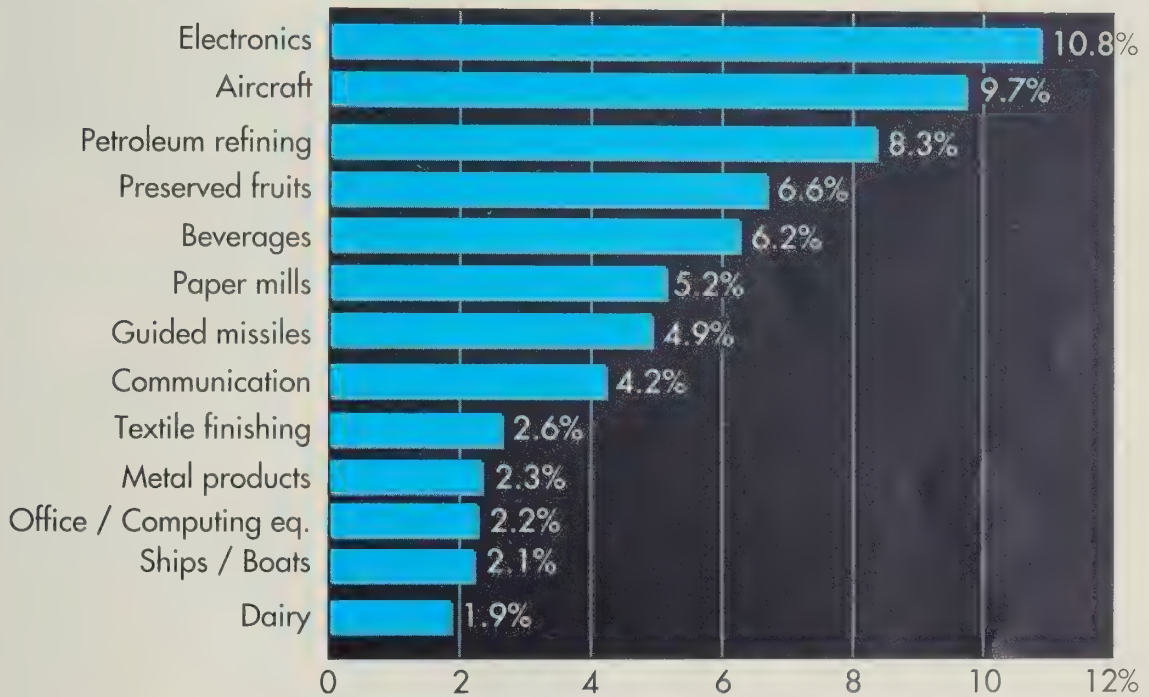
<i>PER ESTABLISHMENT</i>	<i>5,600 gallons per day</i>
<i>PER EMPLOYEE</i>	<i>127 gallons per day</i>
<i>PER PERSON (capita)</i>	<i>12 gallons per day</i>



*\*Includes irrigation, dust control, and other outdoor uses.*



**Figure 11**  
**THE LEADING MANUFACTURING USERS OF MWD WATER**



Note: Other manufacturing users make up 33.23% of total industrial water users.



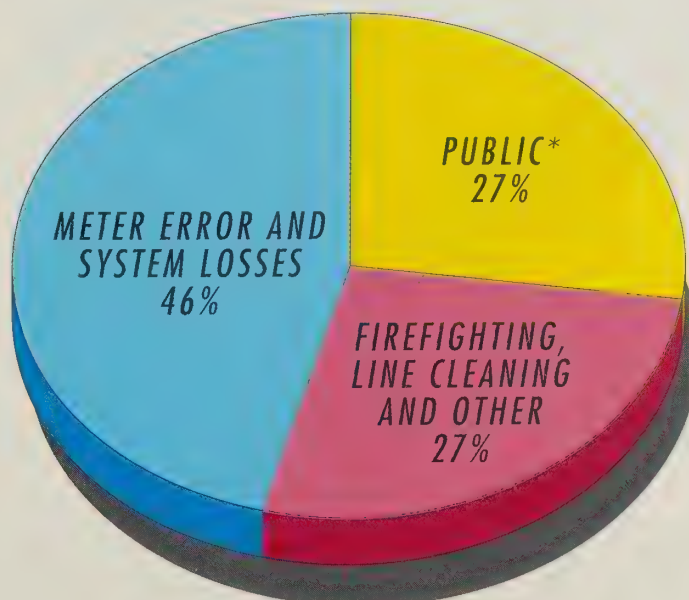


## PUBLIC AND OTHER WATER USE

The last major category of M&I water demand is public and other. This category represents about 11 percent of total M & I use and can be broken down into authorized and unauthorized uses. The authorized uses of water classified in this category include: (1) fire fighting; (2) street cleaning; (3) line cleaning, and (4) hydrant flushing. The unauthorized uses include: (1) meter error; (2) illegal connections;

(3) major breaks; and finally (4) system losses due to leaks and evaporation. Figure 12 shows the breakdown of this sector. Almost half of this sector's water use is meter error and system losses. About one-quarter is public uses, which includes irrigation of public areas and some indoor uses, and the remaining quarter is authorized unmetered uses such as fire fighting and line cleaning.

**Figure 12**  
**CATEGORIES OF PUBLIC/OTHER WATER USE**  
*(Represents 11 percent of total M & I use)*



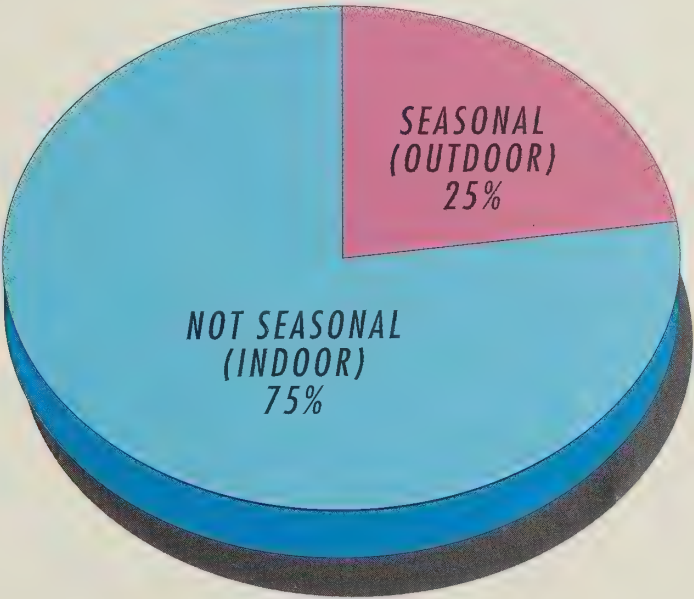
*\*Public use includes irrigation of public areas and some indoor uses.*



Because of the nature of this type of water use, it is very difficult to determine how much is used seasonally. Figure 13 presents a working estimate of the seasonal breakdown of public and other water use. Most of the water use is estimated to be nonsea-

sonal, in other words, does not fluctuate greatly from month to month. About 25 percent of the water use is estimated to be seasonal, or closely equivalent to outdoor water use.

**Figure 13**  
**SEASONAL BREAKDOWN OF PUBLIC/OTHER WATER USE**





SUMMARY OF M&I WATER USE  
IN METROPOLITAN'S SERVICE AREA

Water Use Sector	<u>PERCENT OF ANNUAL USE</u>		
	Disaggregation of M&I Use	Indoor Use	Outdoor Use
<b>RESIDENTIAL:</b>			
Single-family	45	65	35
Multifamily	21	82	18
<i>Total Residential</i>	<i>66</i>	<i>69</i>	<i>31</i>
<b>NONRESIDENTIAL:</b>			
Commercial/Institutional	17	71	29
Industrial	6	79	21
<i>Total Nonresidential</i>	<i>23</i>	<i>73</i>	<i>27</i>
<b>PUBLIC AND OTHER:</b>			
Public	3	25	75
Fire Fighting, Line Cleaning, and other	3	80	20
Meter Error and System Losses	5	100	0
<i>Total Other</i>	<i>11</i>	<i>75</i>	<i>25</i>
<b>TOTAL M&amp;I USE</b>	<b>100</b>	<b>71</b>	<b>29</b>





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